Conditions Of Polish Industry Innovativeness

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Abstract

One of the measures of Polish economy development, including its innovativeness and competitiveness is the level of gross domestic expenditures on research and development activity, so called GERD in relation to gross domestic product, i.e. GDP[1]. Poland assigns for R&D one tenth of expenditures, which are assigned by countries with the highest index GERD/GDP: USA and Japan. Scientific and research-development units in our country are characterised by a relatively low level of investment expenditures. As a result, small rebuild scientific-research apparatus and high level of its wear occur. The level of expenditures on R&D per capita in Poland and small share of industry in financing research are reasons of still unsatisfactory pace of decreasing the distance between Poland and well - developed countries (including the EU countries). Lack of mechanisms encouraging industry to greater participation in expenditures on R&D destimulates innovativeness and competitiveness of economy. The paper presents indexes characterising the innovative potential of Polish economy against the background of selected countries. It analyses positive aspects and barriers of innovativeness growth. These problems make a subject of many years research and analyses carried out by authors presented among others in works [1], [2]. The paper described some trends and conditions occurring in Polish economy undergoing transformation. It presents an example of using a method of artificial neural networks in modelling innovativeness in industry on an example of the innovation intensity index. Research method proposed by authors, carried out with the use of a method of artificial neural networks confirm that positive trends concerning Polish industry innovativeness in the first years of the XXI century are maintained.

Analysis of innovativeness indexes in Polish industry

On the basis of statistical data from several years a relatively reliable assessment of innovative potential of Polish economy can be done. The most important indexes in assessment of the economy's innovative potential and ability to create high-tech industries are among other [5, 7, 8]:

- Level of absolute expenditures on R&D,
- Percentage share of national industry in expenditures on the country's R&D activity,
- Level of gross national expenditures on R&D to the gross national product, i.e. GERD/GDP,
- Share of innovative enterprises amongst all the enterprises in the country, called the industry innovativeness index,
- Share of expenditures on innovative activity in sold production, index called innovativeness intensity,
- Level of gross national product per capita,
- Level of research-development apparatus wear.

In Polish economy growth tendencies concerning absolute amount of expenditures on R&D in world prices are observed. GERD expenditures with reference to GDP were at the same level during three succeeding years

Readers with comments or questions are encouraged to contact the authors via email.

[1] Defined as GERD/GDP index [8, pp. 42].

1996-1998 and amounted to 0.72%. On the other hand, in 1999 the discussed index increased by 4.1% and amounted to 0.75%. However, it was still 3-4 times lower than in countries such as USA and Japan. For comparison: on average this index in 1997 in OECD countries, member of which is Poland, amounted to 2.21%, whereas in EU member countries 1.82% [5], [9].

GERD index covers all expenditures in a particular year on R&D on the territory of a given country independently of the origin of resources, i.e. together with means obtained from abroad (export of R&D). However, it does not cover resources spent on R&D executed abroad (import of R&D). In internal expenditures on R&D current and investment expenditures are taken into account, but fixed assets amortisation is not taken into account to ensure comparativeness of data from different countries. Addition of amortisation costs would cause double calculation of the same sums. Moreover, real sums of amortisation allowances are useless in international comparisons because of different tax regulations [5]. Table 1 presents selected indexes of innovative potential of Polish economy.

Table 1. Indexes of Polish economy's innovative potential in the period of 1997-1999[2] in dollars)

No	Specification	1997	1998	1999
1.	Expenditure on R&D in mln USD	1024.4	1143.0	1106.7
2.	The share of investment expenditure on fixed assets in expenditure on R&D in %	17.7	19.6	19.5
3.	The machinery share in investment expenditure in %	71.9	70.3	71.3
4.	Expenditure of industry on R&D in mln USD	323.3	395.7	375.6
5.	The share of industry on R&D in %	31.6	34.5	33.9
6.	Relation of GERD to GDP in %	0.72	0.72	0.75
7.	GERD per capita in USD according to PPP[3]	56.5	60.9	.
8.	The wear of R&D equipment extent in %	70.8	70.8	69.9

Source: [1], [2], [7] and own calculations [9], [10]

Expenditure on R&D in industry in 1999 made ***33.9%*** of expenditures on R&D in Poland (own resources of industry made 66.4%). Index of industry share in these expenditures was in 1999 considerably lower than the level of this index in highly developed countries, e.g.

USA ***67.4%,***
Japan ***58.1%,***
Great Britain ***64.2%*** [6].

According to world trends, the share of industry in added value in highly developed countries decreases. Services are dominant, even in ca. 60 %. To cope with the economy's competitiveness and innovativeness industry must continuously improve products, technology and manufacturing technology. It causes a need to spend enormous means on R&D by industry. It is necessary to keep a position in world economy, what is expressed by a share in export.

The level of expenditure on R&D per capita, according to PPP, in Poland (60.9 USD) significantly strays from the level in developed countries (e.g. in USA in 1997 the index was at the level 794.4 USD, in Germany – 510.6 USD). For comparison in the Central European countries this level in 1997 was also higher and amounted to: in the Czech Republic 154.9 USD and in Hungary 72 USD [8]. According to authors estimated calculations the level of expenditure on R&D per capita, according to PPP, in Ukraine in 1997 was 25.6 USD [11].

[2] Data of innovative potential based on statistical data of the Main Statistical Office of Poland, which are published with a year delay and comprise information till 1999.

[3] PPP - purchasing power parities expressed in US dollars means value of US dollar corresponding with a unit of a particular country currency on the national market, covering the whole of goods and market and non-market services with taking into account relation of a particular country's prices to prices of all other countries taking part in comparisons of purchasing power parities [8]

Efficiency of research-development and innovative activity conditioning the increase in enterprise competitiveness significantly depends on the development strategy. R&D intensity (the level of expenditures, access to and supply with external financial sources, number of persons employed in research activity, level of their knowledge, creativity, mobility) significantly influences the level of innovativeness. In the beginning period of Polish economy transformation, when the most important goal for the majority of enterprises was to "survive", first made decisions concerned closing down extended structures of R&D departments. Enterprises competing for ready market did not care of co-operation in the area of protection of the research-development potential. Resignation from R&D activity in enterprises was limited by high costs of this sphere. However, it appears from the Main Statistical Office data that enterprises which managed to maintain own research-development base are characterised by high innovativeness (Table 2 and 3).

Table 2. Value And Share Of Production And W[4] Sector Activity In Expenditure On Innovations In Polish Industry In 1999.

Specification	Total expenditure on innovation in mln USD	Including		Intensity of innovations in %	Innovativeness %
		R&D	Investments in machinery and technical devices		
Industry	*3676.5*	*681.9*	*1845.4*	4.4	28.9
Including (%):					
Production activity	88.9	98.3	84.5	4.9	30.2
W sector	32.0	52.7	28.8	4.7	50.5

Source: Own calculation [8], [10]

In the W sector, comprising 10 sections of manufacturing activity – the main carriers of technological progress, over 50% of enterprises introduced innovations, i.e. by ca. 20% more than on average in manufacturing activity [2], [10]. Sections of the W sector spent 52.7% of expenditure on innovations (on the basis of [10]). Three manufacturing sections of the W sector were characterised by the highest share in expenditure on innovations (Table 3.).

Table 3. Structure Of Expenditure On Innovations In Sections Of The W Sector In 1999.

Specification	Share in expenditure on industry innovations in %	Including (%)	
		R&D	Investments in machinery and technical devices
W sector	52.7	30.5	45.2
Production of machinery and devices	6.3	42.7	35.7
Production of motor vehicles, trailers and semi-trailers	6.9	20.5	61.2
Production of chemicals and chemical products	7.6	32.3	31.8

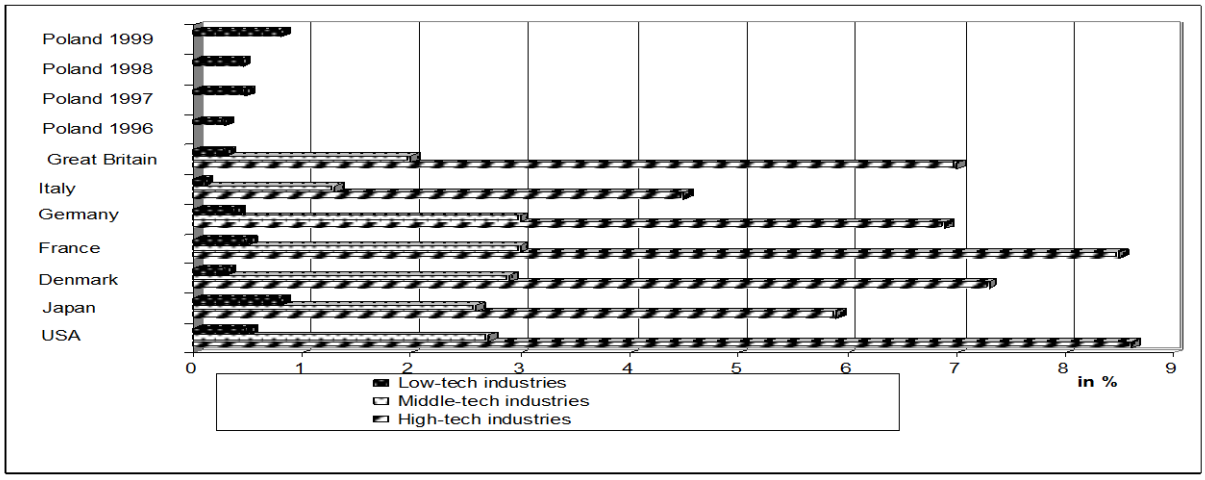
Source: Own calculations [10]

Innovativeness of Polish industrial enterprises is to a significant extent determined by the level of expenditure on R&D in relation to the sold production value. In last years Polish industry on average spent ca. 0.6 % (in

[4] W sector comprises ten sections of manufacturing activity, amongst which seven (production: machinery and devices; office machinery and computers; electric machinery and apparatus; radio, television and communication equipment and apparatus; medical, precise and optical instruments, clocks and watches; motor vehicles, trailers and semi-trailers; chemicals and chemical products) is ranked among high and middle-high tech and three – among middle-low tech (production: goods of rubber and plastics; other transport equipment, waste management [8, pp. 143], [9]

1999 0.8 %) of the sold production value on R&D, i.e. such value as on average was spent by low-tech industries in OECD countries, whereas incomparably less than high-tech industries (Fig. 1).

Fig. 1. Intensity Of Expenditure On R&D According To Technological Advancement Of Industries In Selected OECD Countries (Own Calculation And Calculations On The Basis Of [10], [14]).



Favourable tendencies of systematic increase in a share of foreign investments, mainly in labour consuming branches take place in Poland, what influences achievement of relative predominance in export to well developed countries (this predominance first of all results from labour costs lower than in these countries). Moreover, some symptoms of changing the foreign investment structure have occurred. They consist in shifting capital from labour consuming sectors towards branches with a higher level of technological advancement [2]. A relatively high share of foreign investments in technologically advanced sectors can positively influence the industry structure in the future, tendency to undertake innovative activities and change of the export structure. These factors should favour the increase in Polish industry competitiveness and intensification of the increase in Poland's share in the international labour division. The share of Poland in world export shown growing tendencies: in 1992 amounted to 0.42%, whereas in 1999 to 0.5% (1998 0.6%). The ratio of export to gross national product was also improved – from 25.4% in 1995 to 26.1% in 1999 [8], [9].

Technological development has a character imparting dynamism to economy. It forms changes in technology and social consciousness. So far it has been generally thought that economic development first of all takes place thanks to the most important section of economy, namely industry. Inside industry mainly industries with advanced technology are a factor fostering structural changes. However, positive changes in economy require also favourable salary, price and cultural relations in the whole society. For example, opening of the so-called price scissors in agriculture causes enlargement of deficit in industrial branches manufacturing production means for agriculture.

Technology applied in the society increases the level of its knowledge. Systematic growth in the knowledge level and development of science are complementary to one another and technological progress represents the material side of knowledge transfer to practice. Technological progress determines the production growth and working capacity as well as extorts changes in organisation of work. The latest trends [6] state that the manufacturing process organisation is responsible for at least 30% of savings in costs.

Motives to innovativeness growth

Motives of enterprises to implement innovations are important in assessment of their innovativeness. It

turns out that for enterprises which introduced innovations the most important objective of innovative activity was to increase or keep the share in market (80%) and improvement of goods quality (75%), and to a smaller extent replacement of withdrawing goods (26%) [14].

The price of the product, to a big extent depending on the production costs, is also a very important factor of competitiveness. 66% of enterprises stated the decrease in the production costs as a significant motive of their innovative activity. For big enterprises this factor was at the level of 86%. 72% of big, 62% middle and 50% small enterprises expected the decrease in production costs after having introduced innovations.

Motives of innovative activity are formed under the influence of the character and kind of activity run by firms. In manufacturing activity the main motive power of innovativenes was increasing or maintaining the share in market (83%) and improvement of products quality (78%), as well as looking for new markets (68%) [14].

Currently, information systems, which constitute a very important element of the modern industry surrounding, are thought to play a vital role in the process of production development.

80% of enterprises, which introduced innovations, declared that internal sources, i.e. own R&D facilities, selling and marketing were their main sources of information. 60% of them obtained information from outside, mainly market-commercial information (suppliers of materials and equipment, clients, competitors, consulting firms). Moreover, 53% of enterprises, which introduced innovations used generally accessible information about innovations (patent information, conferences, meetings, professional magazines, fairs and exhibitions) [14, p. 15]. In all the groups of enterprises own sources of information were used to the highest extent, whereas it was in the best manner done by big enterprises employing over 2000 persons. They also to the biggest extent use information from research-development units – 33% as well as market-commercial information – 71%. Information included in scientific publications or obtained as a result of co-operation of scientific workers with industrial staff usually generate very efficient solutions [2], [15].

Effects of research-development work may result from the following activities [6]:

- Generation of new technology in a form of products or processes not known so far,
- Modification of already existing products or processes, what is expressed by their increased effectiveness, wider application and giving additional functions,
- Creation of solutions, which enable efficient monitoring of production processes and at the same time increase in their effectiveness,
- Creation of new research possibilities creating new technology.

It turns out from studies carried out by the Main Statistical Office in 1999 that use of own information about innovations is closely connected with having own research-development back-up facilities. It appears that own R&D activity is the most often run by big enterprises, mainly from the public sector – 65.3% of inquired enterprises and 51.6% of the private sector enterprises. Financial possibilities are decisive for this. The biggest number of enterprises running R&D activity was dealing with manufacture of oil and its derivatives products – 64.3% and production of chemicals and chemical products 55.2% [14].

Unfortunately, few SMEs run R&D activity and few small firms had formal agreements with institutions from the scientific and research-development sphere. Their loose relationships with this sphere do not presage well of SME possibilities to create and implement innovations and require effective system solutions [13].

Directions of Polish economy innovativeness

The most important indications of innovativeness and modernisation of Polish economy (including

industry) are [1]:

- The increase in the share of advanced technology products in value of sold production of industrial goods from 7.8% in 1992 to 11.1% in 1999 [7], [10],
- The increase in export of "high-tech" products from 3.4% in 1993 to 4.8% in 1998 [8],
- The increase in the share of machinery and transport means in export from 19.1% in 1992 to 30.2% in 1999 [9], [10],
- Favourable changes in the economy's energy consumption as a result of introducing market economy in the energetic sector,
- Decrease of energy consuming and arduous for the environment manufacturing companies.

The level of investments in Poland, expressed by the ratio of gross expenditures on fixed assets to gross national product was similar to the one achieved by developed countries. Although the level of these expenditures per capita significantly differs from the value achieved by countries with high level of development, one may note a huge progress achieved in this field in Poland if we compare the level of the expenditures per capita in 1990 (*324.9 USD)* with the level in 1998 (*2050 USD according to PPP).* Data for Poland in comparison with data for developed countries are presented in Table 4.

Table 4. Relation and level of gross expenditures on fixed assets in Poland against the background of selected countries

Specification	**Poland**	**Germany**	**USA**	**France**	**Japan**
Accumulation in a form of gross expenditures on fixed assets in % GDP in 1996	20.7	20.6	17.6	17.6	29.7
Accumulation as above in 1998	25.1	19.2	19.4	18.5	26.2
Gross expenditures on fixed assets per capita in USD according to PPP in 1996.	1379	4372	4898	3612	7122
Expenditures as above in 1998.	2050	4385	5934	3967	6256

Source: own elaboration [11]

Example of method of artificial neural networks applying for prediction of the innovation intensity index

Apart from indexes of economy and industry innovativeness obtained ex post forecasting trends and carrying out effective strategic activities on this basis seem to be very important. Modern heuristic methods (expert methods, artificial neural networks, evolutionary algorithms) enable very effective forecasting activities even in the case of incomplete statistical data [3], [13].

The method of artificial neural networks was used for preparing forecasts of innovativeness of industry, manufacturing activity and W sector activity with the use of e.g. the innovation intensity index (Table 5).

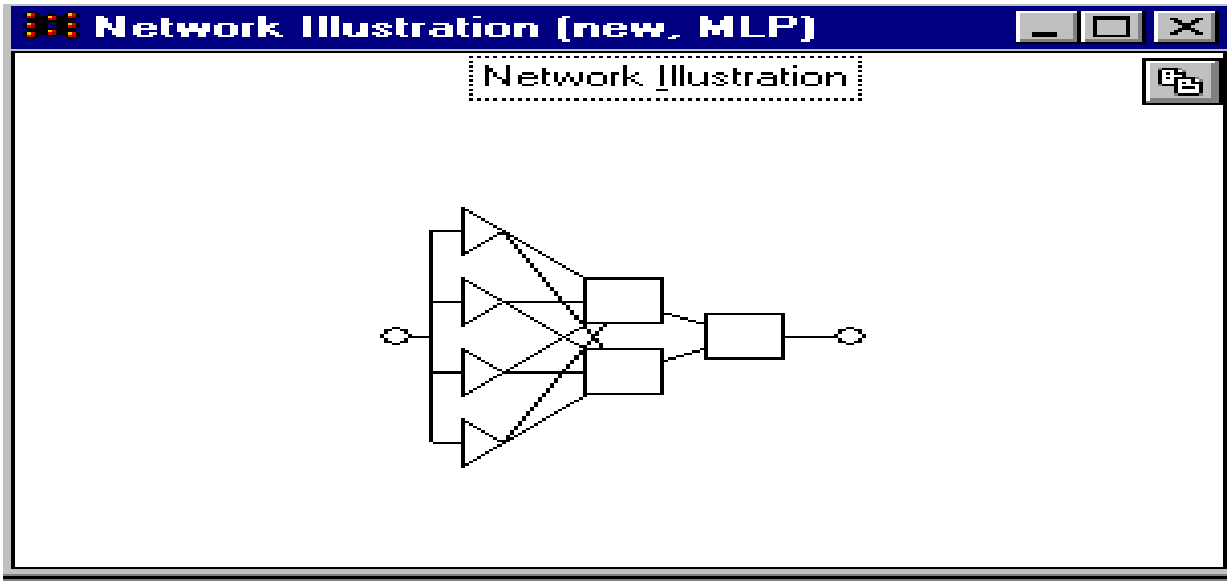
Table 5. Intensity of innovations in industry, in manufacturing activity and W sector in the years 1995-1999

Specification	**1995**	**1996**	**1997**	**1998**	**1999**
Industry	2.1	3.5	3.8	3.8	4.4
Manufacturing activity	2.4	3.9	3.9	4.2	4.9
W sector	2.3	4.7	4.1	4.4	4.7

Source: own calculations [2], [8], [10]

Fig. 2 presents the scheme of the developed neural model of the innovation intensity index in industry. The value of the index for the succeeding period is calculated on the basis of the index value from four previous periods.

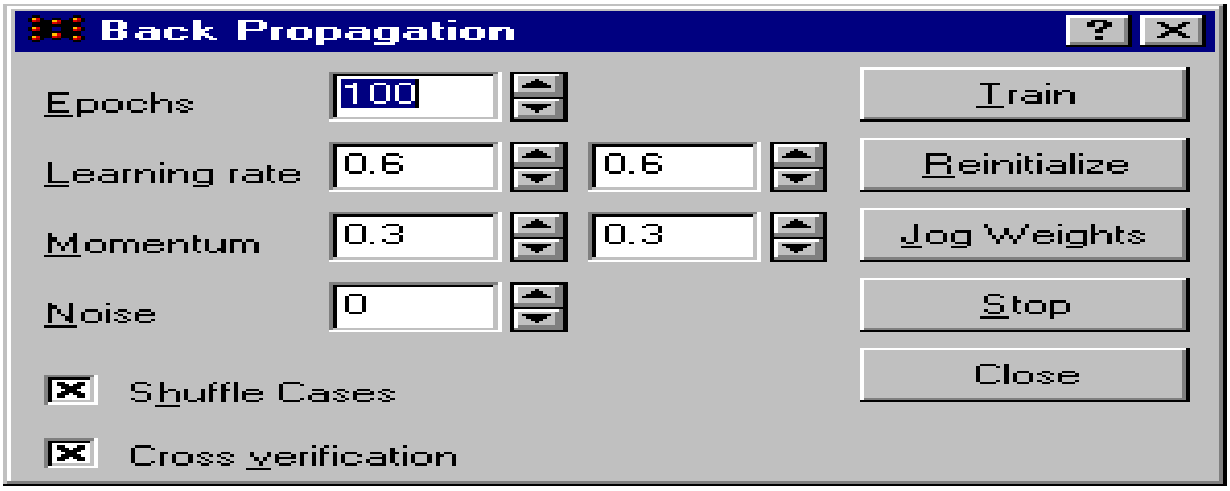
Fig. 2. Scheme of the model of innovation intensity index



The neural model for the presented case is built of three layers: entrance, hidden and exit layers. Software Statistical Neural Networks was used to build this model.

The next step of developing the model comprised the process of determining thresholds of neuron connections – teaching network. In the teaching process data from the period of 1989 – 1997 were used. Fig. 3 presents a window of software environment containing information about the agreed parameters of teaching a selected algorithm network (back propagation).

Fig. 3. Window of the environment Statistical Neural Networks presenting parameters of the teaching algorithm.



As a result of the teaching process thresholds were determined. Fig. 4 shows window presenting values of thresholds of neuron connections in the hidden and exit layers.

Fig. 4. Values of thresholds of neuron connections in the hidden and exit layers.

Network Editor [new, MLP]

Error function: Sum-squared

Layer: 2 Units: 2 Act fn: Logistic

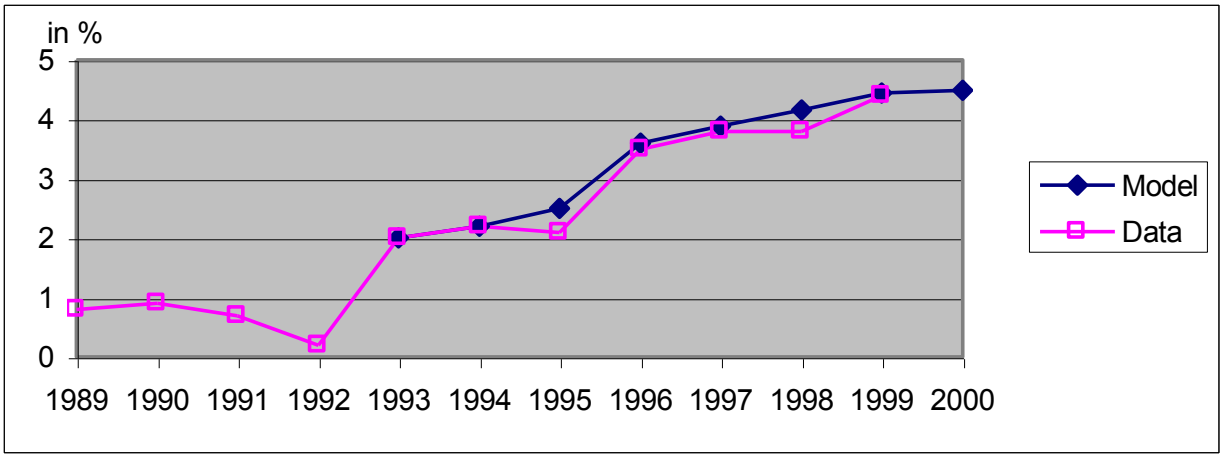
Delete Width: 1 PSP fn: Linear

Connections Shown: Current layer

	h1#01	h1#02
Threshold	0.08854	-1.2
INTENSYW-	-0.4148	-0.09981
INTENSYW-	1.067	-0.1036
INTENSYW-	0.9333	-0.4128
INTENSYW-	1.063	0.06506

With the use of the developed model forecast investigations were carried out. Research results are presented in Fig. 5. Because in the process of building the model data from 1998 and 1999 were not taken into account, forecasts calculated by the model for these years after comparison with data of the real index characterise the model's possibility to forecast future values of the index on the basis of earlier data.

Fig. 5. Values of the innovation intensity index, real data and model's calculations



The calculated relative error of the model (rootmeansquare – RMS related to real values of the index) is about 5%.

Conclusions

- Investment acceleration in the years 1994-1999 in Poland is not able to make up arrears of several decades,

lack of external capital support for enterprises and lack of cheap credits, low level of expenditures on R&D, lack of inclination to invest in production of "high-tech" goods.

- Favourable trends in innovativeness of Polish economy including industry let us hope to gradually level the difference to countries with the highest potential of innovativeness. In Poland a big technical and human potential exist for creation and development of "high-tech" industries. However, there are plenty of limitations of quick development of these activities, among others the most important capital limitation. What concerns this aspect it is difficult to forecast big changes against overproduction in highly developed countries, among others in EU. Thus, there is a need to constantly build own innovative potential on the basis of the development of science and education system, build technical and social infrastructure as well as develop a system of investment stimuli and decrease taxation rates.
- In enterprises it is also necessary to gain social acceptance thanks to training employees, because the level of expenditures on training and improving employees qualifications is one of restraints of still low level of innovativeness in Poland.
- In Poland at present the computer and Internet networks are dynamically developed, what results in improving qualifications in the continuous education system. The present world trend consisting in creation of economy basing on knowledge in a form of using advanced technologies requires continuous improvement of staff qualifications.
- In activities aimed at the increase in competitiveness of Polish economy and in exchange and transfer of technological thought it is necessary to use the best organisational forms as well as create favourable conditions for development of own original forms of knowledge transformation (e.g. technology transfer centres) connected in system supporting innovativeness, mainly in the SME sector.
- Modern information heuristic methods, among others the applied method of artificial neural networks for forecasting indexes of industry innovativeness show significant possibilities of identification of trends occurring in economy and on this basis carrying out effective strategic activities intensifying market competitiveness of Polish products.

References

1. Mazurkiewicz A. Sitkowska R. Modernization as the important factor of the industry restructurisation in the period of transformation. VISNIK of the East Ukrainian State University. Scientific Journal No 5(20) 1999. pp. 72 – 78.
2. Mazurkiewicz A.: Model of dispersed knowledge production in the field of maintenance sciences The International Conference of Maintenance '98 Nyiregyhaza (Węgry) 1998
3. Mazurkiewicz A. Modelling of knowledge transformation into practice in the field of machine maintenance. Instytut Technologii Eksploatacji 1999 (in Polish)
4. Niedbalska G. Badania statystyczne działalności badawczo-rozwojowej (R&D) prowadzone przez GUS. Zagadnienia Naukoznawstwa 4(138). 1998. pp. 461-485
5. Proposed Guidelines for Collecting and Interpreting Technological Innovation Data (The Oslo Manual), OECD, Paris 1997
6. OECD Polska. Przeglądy Gospodarcze. OECD. January 200
7. Popławski W. Mechanizmy procesów innowacyjnych w rozwoju przemysłów wysokiej techniki. UMK. Toruń. 1995.
8. Raport o stanie nauki i techniki w Polsce w 1999. GUS. Warsaw 2000
9. Raport o stanie przemysłu w 1999 r. Ministerstwo Gospodarki. Warsaw 2000
10. Rocznik Statystyczny Przemysłu 1995-2000. GUS. Warszawa 1995-2000
11. Rocznik Miedzynarodowy 2000. GUS. Warszawa 2000.
12. Stan nauki i techniki w Polsce. KBN. Warszawa 1999
13. Mazurkiewicz A.: System-Related models of research results transformation into industrially utilizable solutions. Surface engineering towards the 21/ ST Century. Associate Editors Ma Shining China, 1997 Machine Press. s. 560-564.
14. Wiszniewski W. Niedbalska G.: Działalność innowacyjna przedsiębiorstw przemysłowych w latach 1994-1996. GUS. Warsaw 1998.
15. Wysokińska Z. Aspekty technologiczne konkurencyjności międzynarodowej Unii Europejskiej oraz Polski.

Studia Europejskie 1997. No 2. pp. 87-106.

Notes